

# NASA TECH BRIEF



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## High-Strength Tungsten Alloy with Improved Ductility

As the highest melting metallic element, tungsten is of interest for load-bearing components which must operate at extremely high temperatures. A disadvantage of tungsten is that it becomes brittle at temperatures below about 250°F and alloying to increase the strength often increases this ductile-to-brittle transition temperature.

Extensive studies on alloying effects in arc-melted tungsten have led to the development of an alloy which combines superior strength at elevated temperatures with improved ductility at lower temperatures relative to unalloyed tungsten. The composition of this alloy in weight percent is tungsten-4 percent rhenium-0.35 percent hafnium-0.024 percent carbon (W-4Re-0.35Hf-0.024C). The alloy is prepared by consumable electrode vacuum arc-melting and can be fabricated into rod, plate, and sheet. At 3500°F, the alloy has demonstrated a maximum tensile strength of 75,400 psi, an eightfold strength advantage over the 9,000 psi strength of unalloyed tungsten. Sheet material of this alloy can be bent at temperatures as low as 175°F, compared to 250°F for unalloyed tungsten.

The development of this alloy resulted from the combination of the strengthening effect of a hafnium carbide (HfC) precipitate with the ductilizing effect of small amounts of rhenium. It had been shown previously that carbide precipitates, particularly HfC, significantly increased the high temperature strength of tungsten. Optimization of this system resulted in an alloy with the composition of W-0.35Hf-0.024C. Simultaneously, in a different phase of the tungsten program, it was determined that alloying with 2 to 10 percent rhenium dramatically improved the low temperature ductility of tungsten. Bending at temperatures as low as -100°F is possible in these alloys. Subsequently, it was shown that these two effects can

be combined to result in one alloy with far superior high temperature strength and a slight improvement in ductility over unalloyed tungsten.

The high strength of this alloy is derived from the fine precipitate of HfC, the morphology of which can be controlled by heat treatment. Highest strengths are achieved by heat treating at 4600°F to dissolve HfC in the tungsten-rhenium matrix followed by aging at 2500°F to precipitate the HfC as extremely fine particles, on the order of 500 to 1000 angstroms in diameter. These particles effectively stabilize the microstructure, resulting in the high strength at elevated temperatures.

Although developed primarily for space applications, it is anticipated that this alloy may find use in some industrial applications where unalloyed tungsten is now employed, such as electrical components, die casting materials, and heating elements.

### Notes:

1. Aerospace uses for this alloy include fuel elements for nuclear reactors, turbine buckets for generators in compact power generating systems, and forward edges of future reentry vehicles which will glide rather than fall back through the atmosphere.
2. Inquiries concerning this innovation may be directed to:

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### Patent status:

No patent action is contemplated by NASA.

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Category 03